Revised Soil Erodibility *K*-factor for Soils in the Czech Republic

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Abstract: In the territory of the Czech Republic there are more than 50% of agricultural soils exposed to water erosion; it is a very urgent problem both at present and for the future. It must be solved now when there is still something to be protected. It is rather complicated to describe the soil properties in terms of soil susceptibility to water erosion because it is a complex relation in which many factors participate. For the complex evaluation of all main factors participating in erosion origination it is possible to apply the Universal Soil Loss Equation (USLE). It consists of six factors interacting with each other and participating in the origination of soil erosion. One of these factors is the soil erodibility factor (*K*-factor), the revision of which for soil conditions of the CR is the subject of this study. In total ca. 5000 soil pits from the whole territory of the country were processed and evaluated in detail. The main results of this study are *K*-factor values (means and variances) for the soil types, subtypes and varieties (represented in the database) according to the Taxonomic Classification System of Soils of the Czech Republic.

Keywords: water erosion; soil erodibility; soil structure; permeability; soil texture; organic matter

In the Czech Republic there is more than 50% of agricultural land exposed to water erosion (Janeček *et al*. 2002). It is a very urgent problem at present and mainly for the future. The problem must be solved now when there is still something to protect. It is rather complicated to describe soil properties in relation to soil susceptibility to water erosion because the relation is a complex one and because of many factors participating in it. For comprehensive evaluation of all main factors participating in erosion origination, the most frequently used and best-known equation, that according to Wischmeier and Smith (1978), so called Universal Soil Loss Equation (hereinafter USLE), can be used. It consists of six factors, taking part, through their interactions, in the origination of soil erosion. The soil erodibility factor (*K*-factor) is one of them and its determination for soil conditions of the CR is the subject of this paper.

METHOD

The procedure for *K*-factor determination according to Wischmeier and Smith (1978) was used.

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The main background data for *K*-factor determination were obtained by the evaluation of the computer database of special soil pits (Sp pits) and a part of selective soil pits (Se pits) from the Comprehensive Survey of Agricultural Soils of Czechoslovakia. This database (Novák *et al.* 2005) currently contains ca. 1200 Sp pits and ca. 3700 Se pits. The database of Sp pits is complete and covers the whole territory of the country. The database of Se pits presently contains soil pits from the districts Náchod, Pardubice, Rychnov nad Kněžnou, Ústí nad Orlicí, Blansko, Brno-Town and Brno-Countryside, Zlín, Hodonín, Jihlava and České Budějovice (part). The latter values were used to provide supplementary information for the statistical processing of *K*-factor values.

The database consists of two parts. The first part contains general information on the soil pit and its location, e.g. geographic coordinates, data on soil erosion, data on groundwater table, land use – crop, date of sampling, natural conditions of the site (precipitation, temperature, altitude, slope …) and other climatic and agricultural data. All these items comprise both the original values (ca. 40 years old) and the newly acquired values from recent field samplings. The second part of the database contains complete information on individual genetic horizons of each profile (in fact, it is an ancillary database to the first part), mainly the results of chemical and physical analyses and other, mainly quantitative data (soil structure, living organisms, root systems, new formations, compaction, profile gleyization, colours of horizons and their depths, horizon classification according to several classification systems such as FAO, etc.). Like the first part, the second part of the database contains both the original values and the newly acquired ones. The whole database is administered by the database program MS Access and its statistical outputs are processed by the UNISTAT program.

Method of evaluation

For the adequate determination of *K*-factor values from the basic equation according to Wischmeier and Smith (1978), it was necessary to define for each soil pit the limits of topsoil texture categories, the percentage of organic matter in topsoil (percentage of humus content), the class of topsoil structure and the class of soil profile permeability.

Basic equation for the evaluation of *K*-factor

(Wischmeier & Smith 1978)

$$100K = 2.1M^{1.14}10^{-4}(12-a) + 3.25(b - 2) + 2.5(c - 3)$$

where:

M – expresses the effect of topsoil texture and is calculated as (% silt + % silty sand) × (100% – % clay)

a – % of topsoil organic matter (humus)

b – class of topsoil structure

c – class of soil profile permeability

Evaluation of topsoil textural analysis – *M*

To evaluate the soil texture, the percentage of clay, silt and silty sand particles were used. In textural analyses performed in the past in the CR, the percentage of clay was defined as the content of grains < 0.001 mm. In the methodology for *K*-factor evaluation, however, the content of clay is delimited by the grain size < 0.002 mm. The limits of the grain size of silt and silty sand (0.002–0.1 mm) are also different from the original limits used in Czech analyses (0.001–0.01 mm for medium and fine silt, 0.01–0.05 mm for coarse silt, 0.05 to 0.25 mm for fine sand, 0.25–2.0 mm for medium sand). Therefore, it was necessary to convert old textural categories into the new ones. The contents of the new categories were evaluated graphically by the computer program MS EXCEL from the grain size curve to the nearest 0.5%.

Percentage of topsoil organic matter (humus content) – *a*

The percentage of humus content computed by multiplication with a constant from the total oxidisable carbon content (Cox) is a good enough to estimate the parameter *a* for Czech soils. Cox was multiplied by the value 1.724, which is Welte's coefficient based on the assumption of 58% carbon content in humus (Valla *et al.* 2000).

The percentage of humus content is a standard part of the database of Sp pits. For Se pits, the percentage of humus content was computed from Cox, using the Welte's coefficient.

Class of topsoil structure – *b*

The stability of soil structure is currently an urgent problem mainly due to the intensive agriculture, its disturbance being directly connected with

Table 1. Classes of topsoil structure

Class of topsoil structure	Topsoil structure
1	granular
2	crumb
3	lumpy
4	laminar, compact

soil compaction. Heavy-duty machines, producing high specific pressures, destroy the soil structure after repeated wheel traffic, increase the bulk density of soil, decrease its porosity and permeability, and reduce the life in the soil. Heavier-textured soils are more susceptible to compaction. The consequences are reduced groundwater recharge, acceleration of surface runoff and water erosion, deterioration of conditions for plant rooting and reduction of soil productivity (Novák 2000).

For the calculation of *K*-factor according to Wischmeier and Smith (1978), four classes of topsoil structure are used (Table 1).

The type of soil structure is described by means of a code in the database of Sp pits. If the structure type in the database was identical to that in Table 1, the corresponding class number was attributed to it for the purpose of the *K*-factor calculation formula.

Table 2. Classification of the other types of soil structure in topsoil

Topsoil texture	Class of topsoil structure	Note
Light soils: p/hp	1	
Medium soils: ph/h	3	
	1	on light parent rocks (Table 3)
Heavy soils: jh/jv/j	4	

Table 3. Parent rocks classified as light

Igneous rocks	granites (mainly coarse-grained)
	quartz porphyries
	rhyolites
Metamorphic rocks	gneisses (mainly orthogneisses)
Sediments	(terrace, lake, sea, aeolian) sands
	sandstones
	arkoses
	breccias
	conglomerates

For the other types of soil structure, not appearing in Table 1, or for soils without recognisable structure (structureless horizons), the soil type and geology base were also considered (Table 2 and 3). Light soils (p – sandy, hp – loam-sandy) were placed into class 1, medium soils (ph – sandy-loam, h – loamy) into class 3, medium soils on light substrates into class 1 and heavy soils (jh – clay-loamy, jv, j – clay) into class 4. This classification was done on the basis of common knowledge of the formation of various types of soil structure in relation to soil type and soil-forming substrate.

Class of soil profile permeability – *c*

To estimate the infiltration capacity and permeability of soils, the following information was used:

– The categorisation of Main Soil Units (MSU) into Hydrological Groups (Kuráž & Váška 1998). All agricultural soils of the Czech Republic are grouped into 78 MSU, according to soil classification unit (soil type, subtype, variety...), texture composition, water and air regime, parent material, skeleton content and the depth of soil

Table 4. The categories of infiltration capacity and soil profile permeability used for *K*-factor determination

Class	Main soil units
1	04, 05, 17, 21, 31, 32, 37, 40, 55
2	13, 16, 18, 22, 27, 30, 34, 38, 41
3	01, 02, 08, 09, 10, 12, 14, 15, 23, 26, 28, 29, 35, 36, 51, 56
4	03, 06, 11, 19, 24, 25, 33, 42, 43, 44, 45, 46, 48, 50, 52, 58, 60
5	07, 20, 39, 47, 49, 57, 59, 62, 64, 65, 75, 77, 78
6	53, 54, 61, 63, 66, 67, 68, 69, 70, 71, 72, 73, 74, 76

profile. Each MSU also has a specific production potential. In the course of our work the above-mentioned categorisation was complemented by missing MSU and its contents were verified and updated.
– Database of physical, chemical and morphological characteristics and properties of soils of the Czech Republic (RISWC); from this database the soil-moisture properties were derived for individual MSU.
– The digitised graphical and numerical database of Evaluated Soil-Ecological Units (ESEU – RISWC). This database contains permanently updated and complemented maps of ESEU at a scale 1:5000 for agricultural lands in the whole territory of the CR.

Six classes (Table 4) of soil profile infiltration capacity and permeability from very low (class 6) to very high (class 1) were determined.

RESULTS

Determination of soil erodibility *K*-factor for soil types, subtypes and varieties of the Taxonomic Classification System of Soils of the Czech Republic

The values of the *K*-factor were calculated for each soil pit in the database after processing the above-mentioned data comprising ca. 5000 profiles from the whole territory of the Czech Republic. This set of values was checked and statistically evaluated. The following basic characteristics were determined during the statistical analysis: arithmetical mean, median, standard deviation and variance. If the set of *K*-factor values was not satisfactory (small data set) for a particular soil group, it was discarded (Table 5). Calculated values of *K*-factors for the particular soils: the soil groups with the lowest (Table 6) and highest variance (Table 7).

The soils in the database are classified either according to the old genetico-agronomic classification (Comprehensive Survey of Soils - CSS) from 1967, or according to the morphogenetic classification system of soils (MCSS) from 1991. Therefore it was necessary to reclassify the soil pits, taking into account their descriptions and analytical characteristics, into the currently valid Czech Taxonomic Classification System of Soils (Němeček *et al*. 2001).

This part of the study made it possible to evaluate and quantify the susceptibility of the individual soil groups to water erosion.

The *K*-factor must be multiplied by the coefficient 1.32 to get it in SI units (t.ha.h)/(ha.MJ.mm). The SI-unit values are given in Table 8.

Evaluation of results

When evaluating the results, it is necessary to take into account that only the data on the A-horizon, i.e. on the topsoil, are used for the calculation of *K*-factor, except one characteristic: the soil profile permeability. Many soil types and varieties are distinguished according to traits that lie below the topsoil horizon or according to their soil-forming substrates. This is the reason why apparently different soils can have similar topsoil characteristics.

Group 1 – soils not susceptible to water erosion: *K* < 0.20

Soils: psephitic Regosol, arenic Regosol, pellic Regosol, arenic Chernozem, arenic Podzol.

The positive influence of the light soil texture on the soil resistant to erosion is evident at a glance for this first and least threatened group of soils; light soils with good infiltration capacity and relatively good permeability of the soil profile are among the most resistant. Unfortunately, in some cases (particularly on steep slopes), the soils may have been formed by previous water erosion of the humus horizon (e.g. pellic Regosol).

Group 2 – soils weakly susceptible to water erosion: *K* = 0.20–0.30

Soils: modal Ranker, cambic Ranker, podzolic Ranker, modal Rendzina, cambic Rendzina, modal Pararendzina, pseudogleyic Pararendzina, modal Regosol, arenic Fluvisol, modal Pellic Vertisol, pellic Chernozem, arenic Cambisol, pellic Cambisol, psephitic Cambisol, modal Cryptopodzol, modal Podzol, gleyic Pseudogley.

This is a variegated group. Highly skeletal soils or light soils create a major part of it. It is interesting to observe that the pellic Chernozem (located e.g. in Northern Bohemia in Klapý), susceptible to wind erosion, belongs to this group. It is due to its high humus content and good structure that, in spite of the heavy texture, its *K*-factor is lower than 0.30.

Table 5. Calculated values of *K*-factors for the soil types, subtypes and varieties of Czech Taxonomic Classification System of Soils (Němeček *et al.* 2001)

Soil type	Subtype	Variety	*K*-factor	Mean	Median	Standard deviation	Variance
Ranker	modal		0.20	0.1950	0.1950	0.0003	0.0000
	cambic		0.19	0.1906	0.1831	0.0581	0.0049
	podzolic		0.18	0.1834	0.2233	0.0521	0.0031
Rendzina	modal		0.17	0.1659	0.1659	0.0357	0.0013
	cambic		0.22	0.2249	0.2299	0.0530	0.0046
Pararendzina	modal		0.20	0.1988	0.1926	0.0504	0.0043
	cambic		0.27	0.2739	0.3051	0.0427	0.0020
	pseudogleyic		0.18	0.1788	0.1788	0.0264	0.0007
Regosol	modal		0.17	0.1668	0.1565	0.0496	0.0031
	psephitic		0.13	0.1334	0.1334	0.0362	0.0013
	arenic		0.13	0.1307	0.1244	0.0478	0.0031
	pellic		0.14	0.1397	0.1194	0.0518	0.0032
Fluvisol	modal		0.30	0.2995	0.3024	0.0638	0.0055
	gleyic		0.32	0.3174	0.3179	0.0675	0.0067
	arenic		0.19	0.1943	0.2010	0.0265	0.0009
Pellic Vertisol	modal		0.21	0.2111	0.2068	0.0148	0.0003
Chernozem	modal		0.30	0.3000	0.2908	0.0380	0.0024
	luvic		0.41	0.4066	0.4012	0.0482	0.0031
	phaeozemic		0.26	0.2643	0.2702	0.0637	0.0050
	arenic		0.12	0.1182	0.0911	0.0570	0.0041
	pellic		0.21	0.2109	0.1965	0.0453	0.0032
Phaeozem	modal		0.23	0.2294	0.2371	0.0521	0.0039
	gleyic		0.25	0.2549	0.2548	0.0445	0.0021
	pellic		0.24	0.2400	0.2383	0.0421	0.0021
Orthic Greyzem	modal		0.43	0.4350	0.4233	0.0394	0.0027
	luvic		0.44	0.4446	0.4600	0.0486	0.0033
Orthic Luvisol	modal		0.40	0.4003	0.3866	0.0573	0.0048
	luvic		0.44	0.4385	0.4512	0.0646	0.0053
	pseudogleyic		0.40	0.3994	0.3979	0.0911	0.0083
Luvisol	modal		0.45	0.4547	0.4575	0.0332	0.0016
	pseudogleyic		0.43	0.4270	0.4227	0.0662	0.0062
	arenic		0.24	0.2375	0.2375	0.0312	0.0010
Cambisol	modal		0.25	0.2495	0.2513	0.0610	0.0059
	modal	eutrophic	0.24	0.2435	0.2635	0.0577	0.0058
	luvic		0.38	0.3786	0.3816	0.0463	0.0046
	pseudogleyic		0.26	0.2569	0.2515	0.0439	0.0029
	dystric		0.24	0.2447	0.2390	0.0661	0.0059
	arenic		0.16	0.1551	0.1654	0.0617	0.0057
	pellic		0.23	0.2264	0.2262	0.0587	0.0046
	psephitic		0.23	0.2270	0.1899	0.0500	0.0028
Cryptopodzol	modal		0.16	0.1553	0.1514	0.0538	0.0044
Podzol	modal		0.19	0.1859	0.2057	0.0450	0.0036
	arenic		0.15	0.1512	0.1512	0.0630	0.0040
Pseudogley	modal		0.32	0.3202	0.3210	0.0595	0.0052
	luvic		0.41	0.4113	0.4205	0.0448	0.0025
	gleyic		0.18	0.1782	0.1906	0.0512	0.0044
Gleysol	modal		0.32	0.3205	0.3201	0.0419	0.0027
	modal	peaty	0.35	0.3495	0.3495	0.0094	0.0001

Group 3 – soils medium susceptible to water erosion: K = 0.30–0.40

Soils: cambic Pararendzina, modal Fluvisol, modal Chernozem, phaeozemic Chernozem, modal Phaeozem, gleyic Phaeozem, pellic Phaeozem, arenic Luvisol, modal Cambisol, modal Cambisol var. eutrophic, pseudogleyic Cambisol, dystric Cambisol.

This group contains the soils most frequently occurring in the CR, mainly Cambisols. The group is very variegated, both because of substrates and due to variable pedogenesis. Similarly like in the MSU classification, the soil type Phaeozem belongs entirely to a single group (this one). Modal Chernozem is on the very boundary of this category and should be rather classified into Group 4, i.e. as a highly susceptible to water erosion.

Group 4 – soils highly susceptible to water erosion: K = 0.40–0.50

Soils: gleyic Fluvisol, luvic Cambisol, modal Pseudogley, modal Gleysol, modal Gleysol var. peaty.

Luvic Cambisol is the most threatened soil in this group, while the other soils, mostly occurring in flat lands and possessing a grass cover and humid water regimes, will not be much exposed to water erosion. They may be threatened during floods.

Group 5 –soils most susceptible soils to water erosion: K > 0.50

Soils: luvic Chernozem, modal Orthic Greyzem, luvic Orthic Greyzem, modal Orthic Luvisol, luvic Orthic Luvisol, pseudogleyic Orthic Luvisol, modal Luvisol, pseudogleyic Luvisol, luvic Pseudogley.

In this group, the most threatened soil types, because of their susceptibility to water erosion, are Orthic Luvisols and Luvisols and the soils where a marked process of illimerisation, i.e. the transfer of clay particles through the soil profile, takes place. Their topsoil horizons are often of lighter colour as a result of the ploughing-up of the eluvial (albic) horizon, they have low humus content and are very susceptible to erosion after the soil surface has been disturbed by raindrops.

Group 6 – soils not evaluated because of the lack of data

All the other soils according to the Taxonomic Classification System of Soils of the CR. As for the soil types, they include Lithosol, Colluvisol and Pellosol.

Table 6. Calculated values of K-factors for the particular soils: the soil groups with the smallest variance

Soil type	Subtype	Variety	K-factor	Mean	Median	Standard deviation	Variance
Ranker	modal		0.20	0.1950	0.1950	0.0003	0.0001
Gleysol	modal	peaty	0.35	0.3495	0.3495	0.0094	0.0001
Pellic Vertisol	modal		0.21	0.2111	0.2068	0.0148	0.0003
Pararendzina	pseudogleyic		0.18	0.1788	0.1788	0.0264	0.0007
Fluvisol	arenic		0.19	0.1943	0.2010	0.0265	0.0009

Note: In the soil types Ranker and Gleysol only two values were available, therefore the variance is low

Table 7. Calculated values of K-factors for the particular soils: the soil groups with the highest variance

Soil type	Subtype	Variety	K-factor	Mean	Median	Standard deviation	Variance
Orthic Luvisol	pseudogleyic		0.40	0.3994	0.3979	0.0911	0.0083
Fluvisol	gleyic		0.32	0.3174	0.3179	0.0675	0.0067
Luvisol	pseudogleyic		0.43	0.4270	0.4227	0.0662	0.0062
Cambisol	modal		0.25	0.2495	0.2513	0.0610	0.0059
Cambisol	dystric		0.24	0.2447	0.2390	0.0661	0.0059

Table 8. Calculated values of *K*-factors for the soil types, subtypes and varieties of Czech Taxonomic Classification System of Soils (Němeček *et al.* 2001) in SI units

Soil type	Subtype	Variety	*K*-factor (SI units)	Soil type	Subtype	Variety	*K*-factor (SI units)
Ranker	modal		0.26	Orthic Greyzem	modal		0.57
	cambic		0.25		luvic		0.59
	podzolic		0.24				
				Orthic Luvisol	modal		0.53
Rendzina	modal		0.22		luvic		0.58
	cambic		0.30		pseudogleyic		0.53
Pararendzina	modal		0.26	Luvisol	modal		0.60
	cambic		0.36		pseudogleyic		0.56
	pseudogleyic		0.24		arenic		0.31
Regosol	modal		0.22	Cambisol	modal		0.33
	psephitic		0.18		modal	eutrophic	0.32
	arenic		0.17		luvic		0.50
	pellic		0.18		pseudogleyic		0.34
					dystric		0.32
Fluvisol	modal		0.40		arenic		0.20
	gleyic		0.42		pellic		0.30
	arenic		0.26		psephitic		0.30
Pellic Vertisol	modal		0.28	Cryptopodzol	modal		0.20
Chernozem	modal		0.40	Podzol	modal		0.25
	luvic		0.54		arenic		0.20
	phaeozemic		0.35				
	arenic		0.16	Pseudogley	modal		0.42
	pellic		0.28		luvic		0.54
					gleyic		0.24
Phaeozem	modal		0.30				
	gleyic		0.34	Gleysol	modal		0.42
	pellic		0.32		modal	peaty	0.46

In the new Czech Taxonomic Classification System of Soils of the CR (Němeček *et al.* 2001), Colluvisol was introduced as a new soil type. It is formed by the accumulation of erosion sediments in lower parts of slopes, concave parts of slopes and terrain depressions. These soils have not been mapped yet. Their introduction is useful for the evaluation of actual erosion and identification of deforestation history.

CONCLUSION

This study was focused on soil susceptibility to water erosion expressed by soil erodibility factor *K*. We applied a methodology for its determination which, considering Czech soil conditions, is original. We proposed a new and simplified determination of input parameters while the exactness of computations was maintained. In total

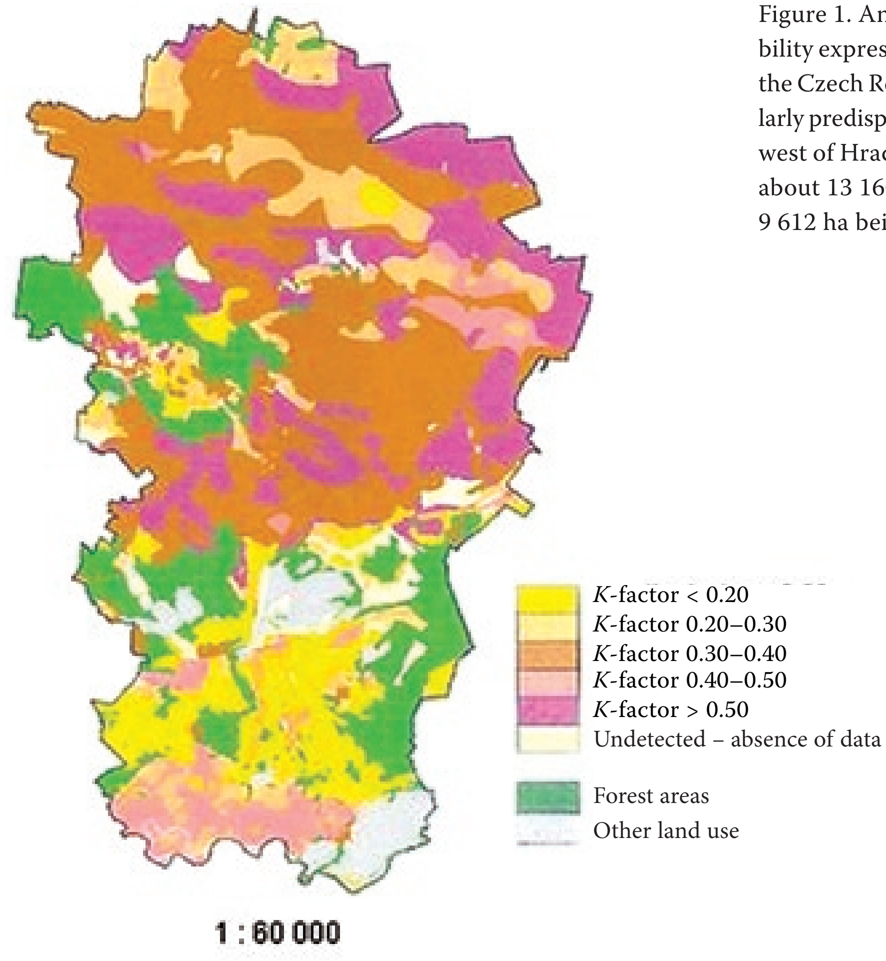

Figure 1. An example of the map of soil erodibility expressed by the *K*-factor for the areas of the Czech Republic where the soils are particularly predisposed to erosion. The area is situated west of Hradce Králové. The size of this area is about 13 160 ha (27 cadastral units included), 9 612 ha being agricultural soils

ca. 5000 soil pits from the whole territory of the CR were processed and evaluated in detail. They included special (Sp pits) and selective soil pits (Se pits) that had been sampled during the Comprehensive Soil Survey (CSS). A large database was built for this purpose. It was then possible to analyse the created sets of data statistically.

The determination of *K*-factor values for soil types, subtypes and varieties (represented in the database) according to the Taxonomic Classification System of Soils of the Czech Republic (Němeček *et al.* 2001) is the main result of this study. Each soil type, subtype or variety properly represented in the database has a computed average value of *K*-factor. Based on these results, it is possible to evaluate the susceptibility of the representative soils to soil erosion very objectively and to create five groups of soils (from not susceptible to most susceptible ones). It was confirmed that Orthic Luvisol and Luvisol were among the most susceptible Czech soils to water erosion. Therefore, these soils should particularly be supervised.

Applying the main results of this study, it was possible to draw up a map representation of *K*-factors for the territory of the whole Czech Republic in the environment of a geographic information system (GIS). This mapping, which is based on the classification of MSU (main soil units) into five or six groups, indicates that in the CR there are ca. 12% of agricultural soils most susceptible to soil erosion, ca. 29% of highly susceptible, ca. 29% of medium susceptible, ca. 19% of weakly susceptible and ca. 10% of non-susceptible soils, while only ca. 1% of soils were not evaluated due to the lack of data. On the basis of the relationship of computed *K*-factors to ESEU (evaluated soil-ecological units), we can use the data on the slope steepness (slope factor *S*) and then by multiplication of the two factors (creating the $K \times S$ product) it is possible to construct a map of potential risks of water erosion for the soils of the Czech Republic. As the (continually updated) digital database of ESEU was derived from maps 1:5000, the values of *K*-factors can be determined in detail for very small areas (Figure 1).

Of course, soil erodibility also depends on the other coefficients of the Universal Soil Loss Equation (the erosivity of the rain, the slope steepness, the length of the slope, the vegetation cover and the efficiency of the erosion control).

List of symbols

USLE – Universal Soil Loss Equation
MSU – main soil units
ESEU – evaluated soil-ecological units
RISWC – Research Institute for Soil and Water Conservation
GIS – geographic information system
CSS – Comprehensive Soil Survey

References

Janeček M. *et al.* (2002): The Soil Protection from the Erosion. ISV, Praha (in Czech)

Kuráž V., Váška J. (1998): Methodology of evaluation of the non productive ecological soil functions. In: Text Book Enviro Nitra, VŠP Nitra, 130–134. (in Czech)

Němeček J. *et al.* (2001): Taxonomic Classification System of Soils of the Czech Republic. ČZU Praha. (in Czech)

Novák P. (2000): The productional and extra-productional functions of soils and their evaluation. In: Text Book of the Czech Pedological Society, Pedological Days 2000, ČZU Praha, 71–84. (in Czech)

Novák P. *et al.* (2005): Numerical Data Base of the Physical, Chemical and Morphological Characteristics and Properties of the Czech Soils. VÚMOP Praha. (in Czech)

Valla *et al.* (2000): The pedological practicum. [Lecture notes.] ČZU Praha. (in Czech)

Wischmeier W.H., Smith D.D. (1978): Predicting Rainfall Erosion Losses. A Guide to Conservation Planning. USDA-SEA, U.S. Governmental Printing Office, Washington.

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